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Soil Moisture Management

Introduction

In Alberta, moisture for crop use is the factor which most frequently limits crop yields and influences the levels of fertilizer and the seeding rates selected. There are two basic sources of moisture for crop use: growing season precipitation and soil-stored moisture received during the nongrowing season. In general, the timing and amount of precipitation cannot be controlled, but management can increase the level of soil moisture storage. This article presents what is known about soil moisture storage and suggests methods for improving it.

The summerfallow-crop rotation has been the traditional method of storing soil moisture. In recent years, this rotation has been shown to contribute to wind erosion, dryland salinity and the loss of organic matter, all of which degrade soil. Increased soil moisture storage will not eliminate these problems or the summerfallow-crop rotation, but can increase the acreage of land suited to annual cropping and improve crop yields.

The level of soil moisture storage currently found across Alberta will be shown. How management such as cultivation, stubble conservation and climate affects soil moisture storage will be indicated. The potential of snow management techniques for increasing soil water storage will be illustrated.

Soil zones and soil moisture guide for recropping

For discussion of soil moisture storage, Alberta can be divided into areas. Figure 1 shows the division of the province into suitable soil areas. These are the same zones used by the soils branch of Alberta Agriculture for fertility recommendations. The soil zone corresponding to each number in figure 1 is given in table 1.

Before a crop is seeded on stubble, experience has shown that certain levels of soil moisture are required if the risk of drought is to be minimized (table 1). These suggested levels of soil moisture do not guarantee a crop or a positive economic return, but together with

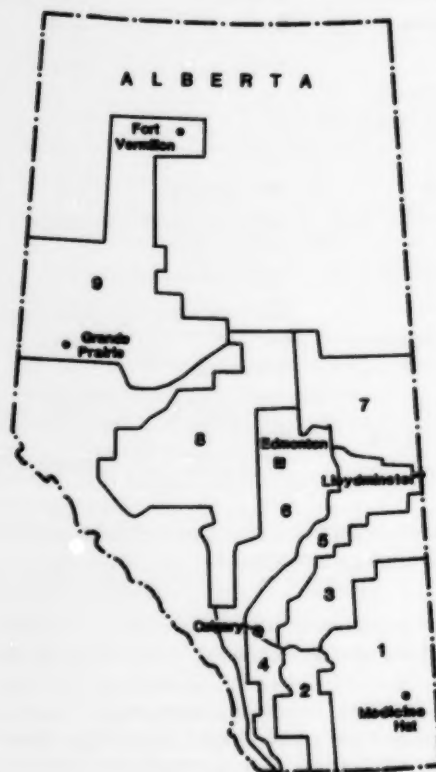


Figure 1. Soil moisture storage areas of Alberta.

normal precipitation patterns and crop prices, these soil moisture levels will provide acceptable yields.

The levels of storage expected

The amount of soil moisture stored varies with the soil zone and from year to year. In the Brown and Dark Brown soil zone, 40 - 45 per cent of the overwinter precipitation will be stored where fall tillage is limited to a single cultivation. Eliminating fall tillage can increase

storage by 5 per cent while tillage which completely destroys the stubble will reduce winter precipitation storage by 10 - 20 per cent. In the Black, Dark Grey and Grey Wooded soil zones, overwinter storage of 25 - 30 per cent of precipitation is typically expected. Thin Black soils will have intermediate storage levels.

Factors that affect moisture storage are the timing of precipitation, stubble height and condition, soil wetness, chinook winds, soil characteristics and the snow melt period.

Rainfall is more effectively stored than snow, so rain after harvest and after spring melt is very important

in building soil moisture reserves. Small rains of less than 10 mm will be lost to evaporation but larger amounts of rainfall will push some of the moisture deep enough in the soil to be stored.

Stubble, like a miniature snow fence, traps snow to the height of the stubble before allowing snow movement out of the field. Stubble also reduces water evaporation from the soil's surface by reflecting sunlight and reducing wind speed at the ground surface. This will be particularly important in the chinook zone where permanent snow cover often does not occur.

Table 1. Soil moisture reserves necessary for recropping*

Soil Moisture Reserves	Soil Zone and Number (Figure 1)				
	1	2 and 3	4 and 5	6, 7 and 8	9
	Brown Soil	Dark Brown Soil	Thin Black Soil	Black, Dark Grey, Grey Wooded Soils	Peace River Region
High soil moisture beyond 75 cm (30 in.)	Yes	Yes	Yes	Yes	Yes
Medium soil moisture to 45 - 75 mm (18 - 30 in.)	Recropping risky except at high end	Yes	Yes	Yes	Yes
Low soil moisture to 45 cm (18 in.)	Recropping not advisable	Recropping risky	Recropping has some risk	Yes	Recropping risky in drier regions
Very low little moisture Below 15 cm (6 in.)	Recropping not advisable	Recropping not advisable	Recropping has some risk	Yes	Recropping risk depends on sub region

* Assumes a loam soil. For clay soil (fine texture), multiply depth in table by 0.7 and for sandy soil (coarse texture), multiply depth in table by 1.5

Soil moisture at freeze-up affects the storage of subsequent rain and snowfall. Soils below 50 per cent available moisture have intake rates very similar to dry soil. As moisture increases towards field capacity, however, intake rates are reduced. Lower intake rates mean more runoff and less storage. This is one of the reasons for the expected differences in soil moisture storage efficiency in the different soil zones.

Soil properties play a role in moisture storage. Soils that crack, such as clay loams and clays, can store more moisture because of the cracks that occur. Research work done in Saskatchewan measured storage increases of 20 - 25 per cent in cracked soil. Deep tillage can provide artificial cracks which can serve the same purpose, but whether this is economical is not known. Normal surface cultivation generally does not improve storage because it reduces stubble height and density. Adverse soil conditions such as the shallow hardpan found in solonetz soils will generally reduce soil

moisture storage by restricting water movement into the subsoil.

Expected level of precipitation and storage

Each soil zone as shown in figure 1 has its unique levels of nongrowing season precipitation. These, represented by the mean, lowest and highest levels received between September 1 and April 30, are summarized in table 2 along with the projected level of winter storage. Spring soil sampling has shown that the storage levels in table 2 have often been exceeded in the Black and Grey Wooded soil zones in recent years.

The potential impact of snow management on soil moisture storage

The ability of the soil to increase the amount of moisture it stores through snow management has been

Table 2. Precipitation and soil moisture storage by soil zone

Soil Zone	Map No.	September 1 - April 30 Precipitation in mm			Storage in mm		
		Average	Low	High	Average	Low	High
Brown Soil	1	145	85	220	65	40	100
Dark Brown Soil							
South Bow River	2	200	110	280	90	50	125
North Bow River	3	160	85	230	70	40	105
Thin Black Soil							
South Bow River	4	240	150	350	95	50	120
North Bow River	5	165	100	230	60	35	75
Black Soil	6	180	110	250	60	35	75
Dark Grey and Grey Wooded							
Northeast of Edmonton	7	180	110	230	60	35	70
West of Edmonton	8	190	115	280	60	35	90
Peace River							
South	16	240	150	320	75	45	100
North	16	170	110	240	50	35	70

documented by research done in the Dark Brown and Brown soil zones in Saskatchewan. Increases in storage can vary from a small percentage up to about 20 per cent of total precipitation, but the most common methods will generally provide for a 10 per cent overall increase in soil-stored moisture. This 10 per cent is approximately equal to one-half of the storage achieved during a summerfallow year.

Snow management to increase soil moisture levels requires some method to retain snow, sufficient snow to collect, a soil able to take in the moisture and melt conditions; hence, the additional amount retained will vary from place to place and year to year. Ideally, the extra stored moisture will permit annual cropping, but that decision must consider the minimum moisture levels suggested by soil area in table 1.

In areas where the minimum recommended soil moisture reserves are not achieved, a rotation utilizing summerfallow every three or four years or a flex cropping system may be adopted. Annual cropping is the most likely selection in the Thin Black and Dark Brown soil zones, while limited summerfallowing or flex cropping would be the more likely choice in the Brown soil zone. In these regions, snow management will potentially increase yield by 3 to 5 bushels per acre beyond that achieved without these practices.

In areas where annual cropping is now practised, snow management can create additional storage most years, but not every year, because surplus water will occasionally occur. Potential yield increases of 4 to 5 bushels of wheat would be possible from snow management during dry years, with less of a yield increase in wet years.

Snow management methods

A number of snow management methods are listed in table 3. Each method will require adjustments to fit each farm operation. In some cases, specialized harvest equipment or seeding equipment may prove desirable. There also will be regional differences in suitability, for what works well in one area may not work in another area. There is a range of storages possible (table 3). To estimate the probable storage, use the storage efficiency of the selected method in table 3 times the expected precipitation from table 2. This will give the average millimetres of overwinter moisture storage expected for that particular storage method.

Any method utilizing stubble requires the preservation of the stubble and generally means no fall cultivation. If fall weed control is required, chemicals should be used. These methods are easy to adopt in management systems utilizing zero or limited tillage. Snow will collect in the stubble to its height before loss from the field will occur. In fields with barriers, wind movement is altered and snow will collect both up and downwind of the barrier. Collection can, in some cases, equal the height of the barrier. The location and uniformity of this snow depends on the density and height of the barrier. Other barriers affect snow accumulation in a similar manner. Barrier placements depend on height, with recommended distance between barriers never exceeding 20 to 30 times the height of the barrier. In many cases, the distance between barriers will actually be dictated by combine or swather width.

The various management techniques will be of greatest benefit in the Brown and Dark Brown soil zones

but will work in other soil zones.

Potential problems

As with any management system, snow management has some potential limitations. Snow management may delay the start of seeding. This occurs because snow filled stubble remains wet longer than land with less snow accumulation. Stubble itself reduces the surface evaporation by 10 per cent promoting wet conditions at seeding time. Wet soil with standing stubble will also be colder than bare soil. There are two reasons for this: first, wet soil warms up more slowly than dry soil, and second, the stubble insulates the soil surface. Ger-

mination is poor at temperatures below 5° C. This moisture related problem will be most noted in the Peace River region. However, this region could benefit in most years from any extra soil moisture and by the protection stubble provides against water erosion.

An adverse soil structure that restricts water intake may increase the size and occurrence of temporary slough areas which may also delay seeding operations.

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Table 3. Snow management methods

Method of snow management	Precipitation storage level as %*		Comment
	Range	Average	
1. Stubble conservation	25 - 50	45	This method is simply the conservation of existing stubble with one fall cultivation. No additional farm costs will occur.
2. Noncompetitive barriers			Fields are snow plowed across the prevailing wind direction to create snow ridges which catch further snow. Results have not been consistent.
• Snow ridging	25 - 50	45	
• Tall stubble	25 - 55	50	Crop is harvested leaving a 25 - 30 cm stubble to catch snow. Seeding requires equipment suited to heavy trash. Little additional costs should occur.
• Alternative height stubble	25 - 60	55	Stubble is cut at alternative heights 10 - 15 cm and 25 - 30 cm. Most conveniently done by two swathers or a combine.
• Standing grain strips	30 - 70	65	Several rows of standing grain are left. This may be done each round or after two rounds. A small decrease in current yield but no additional cost is incurred.
• Deflectors on combine or swather	30 - 65	60	Deflectors on cutting bar leave a strip of stubble with only head removed on each machine pass. A tall crop is generally required to be effective. Little additional cost will be incurred.
• Combine or swather attachments	30 - 70	65	Requires purchase of special equipment. Strips are left on each machine pass.
3. Competitive barriers			
• Grass barriers	30 - 70	65	Permanent grass barriers of wheat grass are established. Some cost involved in grass establishment and maintenance. Barriers occupy a small amount of land.
• Annual crop barriers	25 - 65	55	Barriers are seeded on fallow in mid July and increase snow catch during the following winter. Requires narrow seeder to plant several crop rows. Can be employed on summerfallow.
• Shelterbelts	25 - 50	45	Shelterbelts provide a permanent barrier. They require establishment, maintenance and occupy land. Snow accumulation is often variable and not uniformly distributed.
4. Deep cultivation	Soils that crack can store 25% more water than soils that do not crack		Artificial cracks can be produced by several tools, such as the rippers or paraplovers. The cracks remain active for several years. The economics of such tillage practices have not been established. Deep tillage can be expensive.

* These storage efficiencies are for soils in the Dark Brown and Brown Soil Zones. Other soil zones may exhibit somewhat lower storage as will the area with frequent chinooks.

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